MANITOBA CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

Canada

MANITOBA

LOW ENERGY HOUSING

Flair Homes

Winnipeg, Manitoba

3 (80-41)

MD-11770

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MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program has a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

TABLE OF CONTENTS

1.	Executive Summary	1
2.	Introduction	3
3.	Building Descriptions	3
	3.1 General	3
	3.2 Building Areas	3
	3.3 Exterior Walls	4
	3.4 Basement	4
	3.5 Ceiling and Roof	4
	3.6 Windows	4
	3.7 Insulation	5
	3.8 Lighting	5
4.	Heating and Ventilation Systems	
	4.1 Heating	6
	4.2 Ventilation	6
5.	Air Leakage Testing	
	5.1 Air Infiltration	6
	5.2 Test Results	7
6.	Design Heat Loss and Annual Heating Load Estimates	8
7.	Post - Construction Monitoring	9
8.	Economic Analysis	11
9.	Conclusions and Recommendations	11
	Appendices:	
	A Floor Plan and Wall Cross Section	13
	B Air Leakage and Blower Door Description	17
	C Air Leakage Test Results	23
	D HOTCAN Analysis	31
	E Photographs	37

1. EXECUTIVE SUMMARY

Flair Homes, of Winnipeg, received funding under the Canada/Manitoba Conservation and Renewable Energy Demonstration Agreement (CREDA), to subsidize the construction of an energy efficient house.

The purpose of this project was to demonstrate to other builders and to the public that energy efficient features can be included in high volume construction at reasonable expense.

Flair adapted a conventional 92.7 square meter house design and incorporated energy efficient features, such as a continuous vapour barrier, double wall construction and increased insulation in basement and ceiling areas. Additional features include triple pane windows, maximum glazing on south exposure, and an air to air heat exchanger for ventilation. The house is heated by three electric baseboard heaters with a total rating of 4.5 kW.

UNIES Ltd., Consulting Engineers, of Winnipeg, monitored the construction of the house and performed air leakage tests. The air leakage rate for the completed house was 0.47 air changes per hour at 50 Pascals pressure differential which compares very favourably with other energy efficient houses.

The empirical annual space heating load, calculated from actual electrical consumption for the first year of occupancy, was 8,167 kW.h/year. This is significantly higher than the value of 6,176 kW.h/year estimated by use of the HOTCAN computer program. The difference may be attributable to errors in assumptions about occupant lifestyle which were used in the HOTCAN analysis. In addition, excessive operation of the heat exchanger was observed by the monitors; this practise can lead to higher than estimated heating loads. Inadequate heat distribution may also be causing occupants to overheat some rooms of the house in an attempt to obtain comfortable levels in other rooms.

Based on the empirical energy consumption, normalized for an average Winnipeg season, a simple payback period of approximately 16 years was calculated for the cost of energy conserving features, assuming current electrical rates.

RÉSUMÉ ADMINISTRATIF

Les établissements "Flair Homes" de Winnipeg ont reçu des fonds au titre de l'Entente Canada-Manitoba de démonstration des énergies renouvelables et des économies d'énergie (ECMDEREE) afin de permettre la construction d'une maison à faible consommation énergétique.

Ce projet avait pour but de démontrer aux autres entrepreneurs et au public qu'il est possible de construire en série et à des prix raisonnables des habitations à faible consommation énergétique.

La compagnie Flair a adopté un modèle de maison ordinaire de 92 mètres carrés 7, qui comprenait des éléments de faible consommation énergétique tels que: un pare-vapeur continu, des murs à double épaisseur, l'accroissement de l'isolation du sous-sol et du plafond. Les autres moyens utilisés pour économiser l'énergie consistaient de fenêtres à trois vitres, de la multiplication des triples fenêtres sur la face sud et d'un échangeur thermique air-air pour la ventilation. Le chauffage de la maison est assuré par trois plinthes chauffantes électriques dont la puissance totale de 4 KW 5.

La construction de la maison fut contrôlée par Unies Ltd, entreprise winnipegoise d'ingénieurs-conseils, qui fit aussi les tests de fuite d'air. Dans la maison terminée, le taux de changement d'air était de 0.47/h sous une pression différentielle de 50 pascals - ce qui est un bon résultat par rapport aux autres habitations à faible consommation énergétique.

Calculé sur la consommation électrique réelle de la première année d'habitation, le taux empirique annuel d'utilisation thermique était de 8.167 KW h par an. Cela est sensiblement plus élevé que le chiffre de 6.176 KW h par an qui avait été estimé au moyen du programme informatique HOTCAN. On peut imputer la différence aux erreurs d'estimation du mode de vie qui existaient dans l'analyse Hotcan. Par exemple, les contrôleurs du projet remarquèrent que l'échangeur thermique était employé de façon excessive: une telle pratique peut conduire à une utilisation thermique plus élevée qu'on ne le prévoit. Une mauvaise répartition de la chaleur peut aussi inciter les occupants à surchauffer certaines pièces pour que la température des autres pièces atteigne un niveau satisfaisant.

En se basant sur la consommation empirique d'énergie projetée sur la durée d'une saison moyenne à Winnipeg, on a calculé qu'au tarif actuel de l'électricité, il faudrait une simple période de 15 ans pour récupérer le coût de l'installation de conservation énergétique.

2. INTRODUCTION

Flair Homes Ltd. of Winnipeg, Manitoba, received funds under the Federal/Provincial Conservation and Renewable Energy Demonstration Agreement (CREDA) to construct an energy efficient home.

The purpose of this project was to demonstrate energy efficient high volume construction methods to other builders and the general public.

UNIES Ltd., Consulting Engineers, of Winnipeg, were contracted to monitor construction and advise Flair on energy efficient building techniques. Air leakage tests were performed on the structure and a heat load analysis was provided by UNIES in order to evaluate the energy efficiency of the completed house.

3. BUILDING DESCRIPTIONS

3.1 General

The house was built by Flair Homes Ltd. and is located in Winnipeg.

The following energy saving measures were incorporated into this home: high insulation levels, continuous vapour barrier and triple glazing. The south side has the most glazing; the windows on the east and west sides are smaller, and there are no windows on the north side. An air to air heat exchanger is used to reclaim the heat from exhausted air.

3.2 Building Areas

The main floor area is 92.7 square meters (998 square feet) above grade, plus 92.7 square meters in the basement below grade. The floor plan is shown in Appendix A, Figure A1.

The gross exposed house surface area, including windows, is 205 square meters (2,207 square feet).

3.3 Exterior Walls (See Appendix A, Figure A2)

The exterior walls are of double wall construction 30.5 cm (12 inches) thick. The use of 2 x 4 studs inside, with 2 x 3 studs outside allows a minimum interwall spacing of about 15 cm (6 inches) for insulation. The studs are spaced 40.6 cm (16 inches) on centre along the walls. The exterior is finished with stucco on three sides while the south side is finished with pine siding.

3.4 Basement (See Appendix A, Figure A2)

The basement walls are 38.1 cm (15 inches) thick, and consist of a reinforced concrete outer wall, 20.3 cm (8 inches) thick with a 2 x 3 stud wall attached to the inside face. Glass fibre batt insulation was used for the full depth of the inside wall and rigid polystyrene foam board was glued to the exterior wall, extending to 1.22 meters (4 feet) below grade.

The floor structure is a 7.6 cm (3 inch) floating concrete slab resting on a gravel fill foundation. There is no insulation underneath the slab.

3.5 Ceiling and Roof

The roof is supported by trusses installed on 61 cm (24 inch) centres. Ventilation is provided by eave and gable vents. Plywood nailed on 2 x 2 strapping is used to permit a ventilation passage near the ends of the trusses (See Figure A2). If this method were not used, the insulation would restrict the air flow and cause attic condensation problems.

The attic entry hatch is a common air leakage source. To eliminate this leakage, the hatch was installed outside on the northern gable end.

3.6 Windows

Large triple-glazed windows (6.82 sq. m. total area) were installed on the south side to take advantage of solar heat gain. External blinds have been provided to restrict solar gain in the summer and heat loss at night.

In order to prevent excessive heat loss, windows on the east and west sides (3.9 sq. m. total area) are small and there are no windows on the north side.

3.7 Insulation

The main floor walls are insulated with glass fibre batts, and the basement walls are insulated as previously described (Section 2.4). The following table lists the levels of insulation throughout the house:

Table I

Insulation Levels in the Project House

	RSI	R
Main Floor Walls	7.0	44
Basement Walls (average)	3.5	20
Ceiling	10.6	60
Doors	1.8	12

The levels recommended by the 1978 Manitoba Building Code are RSI 5.8 (R33) in the ceiling, RSI 2.1 (R12) in the walls and RSI 1.2 (R7) in the basement to 0.61 meters (two feet) below grade. The levels for this house are well above these recommendations, but are consistent with many super energy efficient houses recently constructed.

A 6 mil polyethylene air vapour barrier envelops the building to minimize air infiltration. The barrier was installed carefully in order to avoid any punctures and the overlaps and joints were sealed with acoustical caulking. In the wall sections the barrier was installed on the outer side of the inside studs to allow wiring and plumbing to be laid in without breaking the barrier (See Appendix A, Figure A2).

3.8 Lighting

Fluorescent lighting is used in all major task areas, such as the laundry, bathroom, and kitchen. This requires less than half the wattage of incandescent bulbs to achieve the same level of lighting. For areas such as the living rooms, incandescent lamps were judged to give a more pleasant colour balance.

In-ceiling light fixtures were not used in order to prevent air vapour barrier penetration, a major source of air leakage in conventional homes. Fixed lighting is mounted on inside walls.

4. HEATING AND VENTILATION SYSTEMS

4.1 Heating

The heating system has been designed so that passive solar gain supplies a portion of the heating demand (see Appendix D, "Monthly Summary of Energy Consumption").

The majority of the winter heating requirement is supplied by three electrical baseboard heaters with a total rating of 4.5 kW. Two of the heaters are installed in the living room. The remaining 1.5 kW heater is located in the basement, with the design intention that the heat will rise to the upper floor.

A small amount of space heating is also obtained from the domestic hot water, which is heated in a conventional energy efficient electric tank located in the basement.

The Flair home is a passive design; that is heat circulation depends on natural convection. Operation of the air-to-air heat exchanger will assist circulation. However, this is not the intended function of this unit.

4.2 Ventilation

An air-to-air heat exchanger was installed to reduce humidity and odour build-up in the tightly sealed house. The exchanger, (Figure C, Appendix E) developed by the University of Saskatchewan, is used to recover heat from the kitchen and bathroom exhaust, at an efficiency of 75%. This recovered heat is used to warm the incoming fresh air. Operation of the exchanger is controlled by a humidistat.

5. AIR LEAKAGE TESTING

5.1 Air Infiltration

Low energy home designs attempt to reduce air infiltration by use of an effective air vapour barrier, weatherstripping and caulking. To measure the effectiveness of these improvements, a blower door assembly can be used (Appendix B). With this method, air is exhausted from the building to create pressure differentials between the inside and outside air. Air leakage can then be estimated from pressure data.

Test results can be compared to known standards for energy efficient housing. One of the useful results for comparison is the number of air changes per hour (AC/hr.), which provides an estimate of the tightness (and therefore the energy efficiency) of a building.

5.2 Test Results

Two air leakage tests were performed on the house, at the following stages:

1. Vapour barrier installed, interior not completed

2. Completed house (See Appendix C for data).

   The leakage rates (expressed in air changes per hour) were reported at pressure differentials of 10 and 50 Pascals. This is equivalent to 15 and 32 km/hr. winds, respectively, over the entire house envelope.

Results:

Test Number 1
(vapour barrier installed but interior not completed)

Air changes at 10 Pascals: 0.17 AC/hr.
Air changes at 50 Pascals: 0.52 AC/hr.

Test Number 2
(house complete)

Air changes at 10 Pascals: 0.18 AC/hr.
Air changes at 50 Pascals: 0.47 AC/hr.

Both tests were conducted according to standard practices at that time: ie. with all doors and windows shut, all plumbing lines sealed, and both heat exchanger vents covered.

No major sources of leakage were found except for one small hole behind the main electrical panel in the north wall. This was likely caused by penetration of the electrical service through the vapour barrier. Leakage through the door and window assemblies was found to be quite low.

These air leakage results can be compared to the rates found in test programs involving 176 Saskatoon homes conducted by the National Research Council.

Table II

Comparison of Air Change Rates

House Description	Air Change Rate @ 50 Pascals
Pre 1945 construction	10.4
1945 - 1960 construction	4.6
1961 - 1980 construction	3.6
Low Energy Home	1.5
Flair Homes	0.5

The air change rate for the Flair home places it below the reference low energy home. This is a good indication of the quality of the air vapour barrier.

6. DESIGN HEAT LOSS AND ANNUAL HEATING LOAD ESTIMATES

A computer analysis of the house was performed by UNIES Ltd. using the HOTCAN program, which is becoming the most extensively used residential energy analysis program in Canada (See Appendix D). The results of the analysis indicated that the design heat loss was 4.37 kW (14,900 BTU/hr) at an outdoor temperature of -31.7°C (-25°F).

These results, along with the distribution of heat loss throughout the structure and the monthly summary of energy consumption, are included in the HOTCAN program results (Appendix D). The solar fraction in the monthly summary is defined as the percentage of the total load met by solar gains. The air infiltration rate used in the HOTCAN analysis, 0.13 AC/hr., is different from the measured rate, 0.18 AC/hr. This is because the former rate takes into account both the natural infiltration and forced infiltration rates. The natural air infiltration rate of 0.03 AC/hr. is estimated using results from the air leakage tests.

The annual heating load was estimated at 6,176 kW.h (2 x 10 BTU) or 66.6 kW.h/sq.m/yr. At the current electrical run off rate of 2.77¢/kW.h, the heating bill would be $171.08 per year assuming a standard occupancy. This estimate depends strongly on assumptions about occupancy and lifestyle which may vary considerably between occupants.

7. POST-CONSTRUCTION MONITORING

The house was kept as a show home until November, 1981. During the period September, 1981 to August, 1982 Manitoba Hydro monitored the electrical load by sub-metering both the main service and space heating system. Pulse Demand Recorders were used to monitor and record the average electrical load every 15 minutes and record the total daily consumption.

Based on data obtained from the Pulse Demand Recorders for the period between September, 1981 to August, 1982, UNIES calculated the empirical space heating load to be 8,167 kW.h. A monthly breakdown of the heat load is shown in Table III.

TABLE III

Summary of Measured Space Heating Requirements of 129 Grandmont During the Period September 1981 to August 1982

Month	Degree-Days (Celsius)	Measured Space Heating Load (kW.h)	Space Heating Cost
Sept/81	172.9	0	$ 0
Oct/81	392.5	373.0	9.44
Nov/81	510.5	1034.3	26.17
Dec/81	959.3	1586.0	40.13
Jan/82	1337.5	1928.0	48.78
Feb/82	911.0	1441.5	36.47
Mar/82	782.2	1065.7	26.96
Apr/82	458.8	636.5	16.10
May/82	155.8	102.4	2.59
June/82	135.9	0	0
July/82	7.7	0	0
Aug/82	74.3	0	0
	5898.0	8167.4	$206.64

The number of degree days (Celsius) for the period September, 1981 to August, 1982 is 5,898, while for Winnipeg the average annual number is 5,923 (based on 30 years of data by Environment Canada). The heat load can be adjusted to a normal year by multiplying by the ratio of degree days; this gives a normalized heat load of 8,202 kW.h/year.

In addition to UNIES' analysis, the Manitoba Department of Energy and Mines monitored the energy useage for the period April 1, 1982 to March, 1983 by obtaining the monthly electrical consumption figures. It was assumed that 14 kW.h/day was used for lighting and appliances, and 14 kW.h/day was used for hot water (based on Manitoba Hydro estimates for average households). The heating load for that period (5,413 degree days) was calculated to be 8,026 kW.h/year which, normalized to an average year, gives 8,782 kW.h/year.

This compares reasonably with the results obtained by UNIES. During the first two months of the time period measured by UNIES the house was used as a show home and this may have affected their results. However, because of the sub-metering of the space heating system, UNIES analysis is considered to be more accurate.

In either case it was not possible to determine the amount of heat that was recovered from appliances, lights and hot water heating, or the heat that was not recovered from block heaters, car warmers and outdoor lights.

As heating requirements strongly depend on occupant lifestyle, estimates may not be representative of actual occupancy conditions. Other researchers have observed that occupants of energy efficient homes tend to maintain higher than average thermostat settings, rationalizing the increase against reduced heat loss. The net effect is that actual heat loads are higher than expected.

Further, insufficient heat distribution in the project home may be contributing to the higher than expected heat loads. The heating is concentrated into the south side living room - this is where the maximum solar gain occurs, and where two-thirds of the electrical heating is located.

As a result, other areas, particularly the north side bedrooms, are not well heated, especially because of the reliance on natural convection. In order to achieve adequate comfort levels in the bedrooms, it is necessary to overheat the living room, which shows up as increased electrical consumption.

Homes that rely on passive solar gain usually can benefit significantly from the inclusion of a forced convection (forced air) heat distribution system. An alternative approach for the Flair home would be to install supplementary electric heating in the colder rooms, so that zone heating may be practised.

Misuse of an air-to-air heat exchanger can also lead to higher than expected consumption. While the building was used as a show home, UNIES Ltd. had noted that on several visits the humidistat was set too low; the air to air heat exchanger was running longer than necessary which increased heating costs. The setting of the humidistat was found as low as 10%, when the recommended setting was 50%.

8. ECONOMIC ANALYSIS

UNIES' estimated annual heating load, normalized to an average heating season, will be used for the analysis. For comparison, the estimated heating load for a similar size home constructed prior to 1975 (without energy saving features) is used. The average consumption for a pre-1975 home is 270 kW.h/square meter/year and the present electrical run-off rate is 2.77¢/kW.h.

Cost of heating pre-1975 home
270 kW.h/sq. m/year x 92.7 sq. m. x 2.77¢/kW.h = $693

Cost of heating Flair Home
8,202 kW.h/year x 2.77¢/kW.h = $227

Annual Savings $466/yr.

The incremental cost figure provided by the builder for the energy saving features was $7,500. Based on covering the incremental cost, the simple payback period can be calculated as:

$$\frac{\$7,500}{\$466/\text{year}} = 16.1 \text{ years}$$

Note that in the Flair home, the heated, insulated basement can be easily converted to living space. This allows some equity and lifestyle benefits that are not taken into account in the simple payback analysis.

9. CONCLUSIONS AND RECOMMENDATIONS:

9.1 The general quality of the energy related components of the house (insulation, vapour barrier, air management system, etc.) appeared excellent. The thermal insulation seemed to have been properly installed to specified levels without major problems, although the erection of the double wall assemblies under winter conditions did prove somewhat cumbersome. The air leakage rate was very low as a result of careful installation of the air vapour barrier.

9.2 The estimated annual heating load was 6,176 kW.h while the actual load was 8,167 kW.h. The difference may indicate that the actual lifestyle of the occupants differs from the assumed lifestyle used in programming the HOTCAN analysis.

It is important that all assumptions be stated when comparing HOTCAN analyses for various buildings. As more data on actual heating loads becomes available, the HOTCAN program should be reviewed and, if necessary, updated.

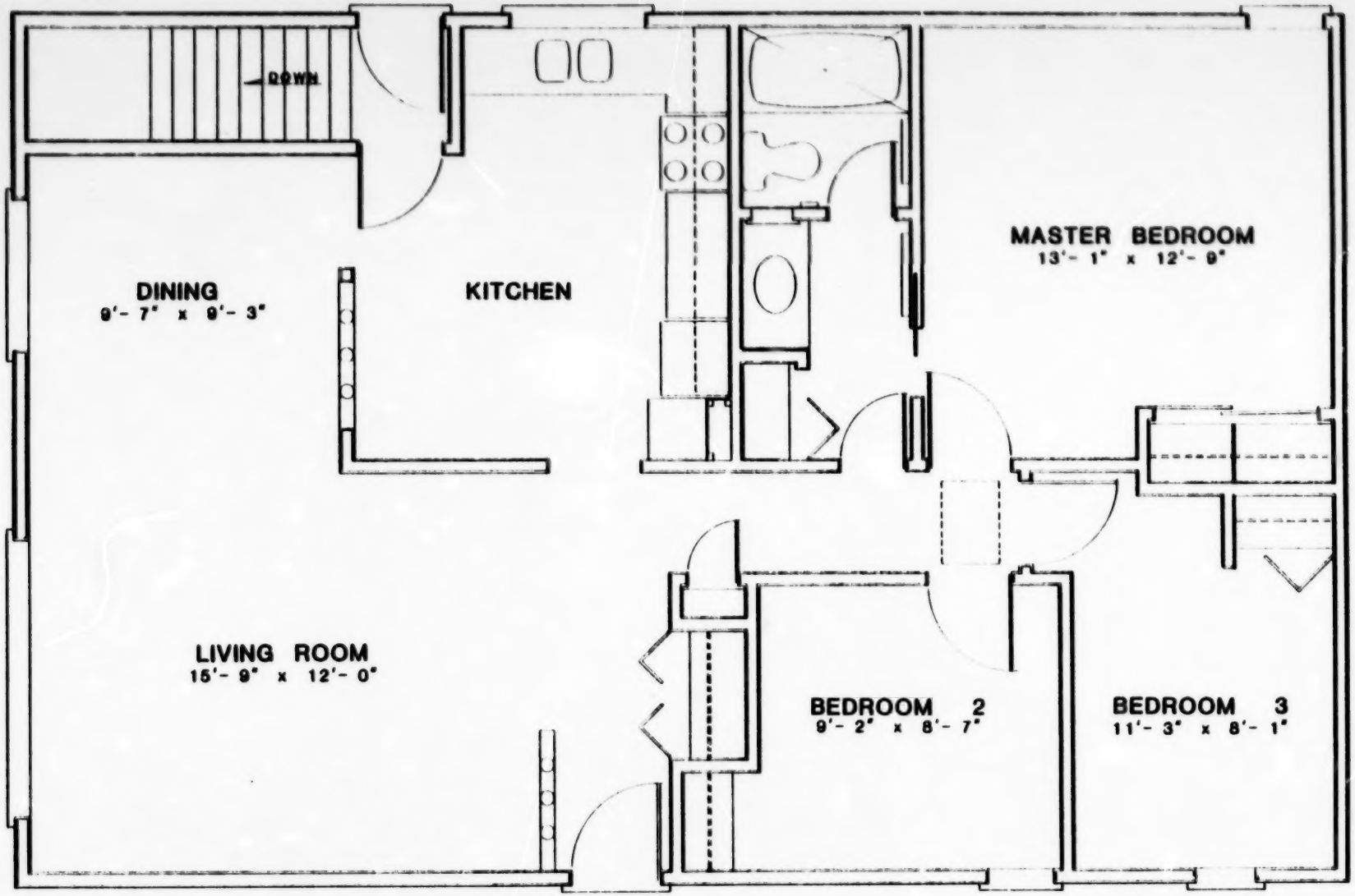
9.3 Proper design of the heat distribution system is essential if the maximum benefits of superinsulation are to be achieved. Forced air systems are useful in passive solar designs, and zone heating is recommended where natural convection is relied upon.

9.4 Maintenance of energy efficiency also requires that greater attention be paid to equipment operation. One problem noted by UNIES during several visits to the house was that the humidistat was improperly set. As a result, the air to air exchanger was operating unnecessarily, thus wasting energy. It is suggested that the importance of proper humidistat settings be made clear to the purchasers of energy efficient houses.

9.5 Based on the results of the first year of occupancy, a simple payback period of about 16 years may be expected on the energy efficient features of the house. This analysis assumes the empirical heating load normalized for an average Winnipeg heating season. As the electrical rates increase, the payback period would decrease making the additions more economically attractive. Changes mentioned above that would improve heat management could also shorten the payback by decreasing the heating load.

APPENDIX A

FLOOR PLAN AND WALL CROSS SECTION



MAIN FLOOR PLAN

APPENDIX A

MAIN FLOOR PLAN

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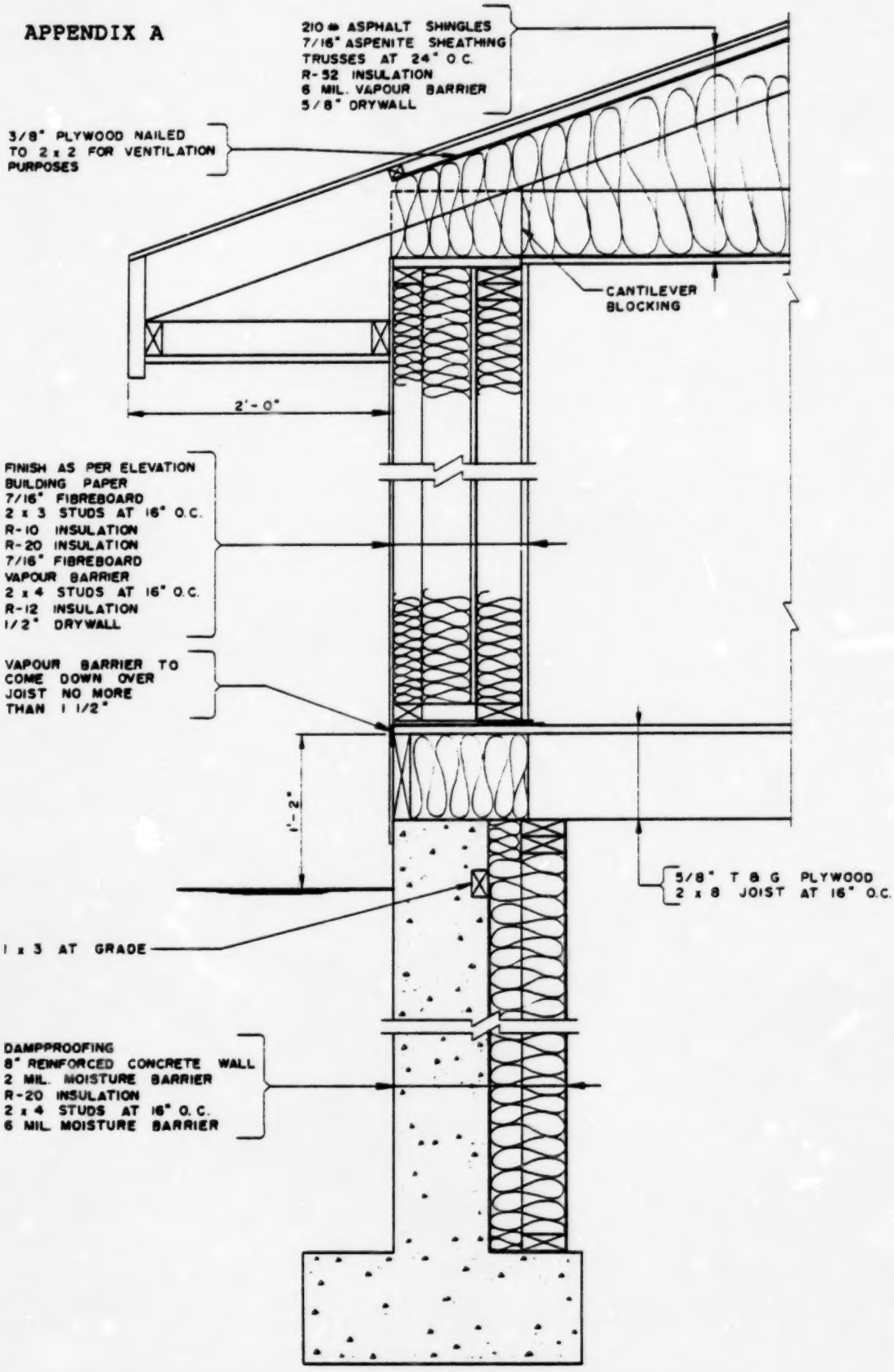


WALL DETAIL

APPENDIX B

AIR LEAKAGE AND BLOWER DOOR DESCRIPTION

AIR INFILTRATION

IMPORTANCE OF AIR INFILTRATION

All houses experience uncontrolled air infiltration to varying degrees. This provides fresh air for breathing, odor and moisture control, as well as supplying combustion air for appliances such as gas or oil furnaces. Unfortunately, this outdoor air must be heated to room temperature and thus constitutes an additional heating load for the furnace to meet. The magnitude of this load is higher than most people realize. In fact, air infiltration is responsible for 15% to 40% of the total heating bill in most Manitoba homes.

CAUSES AND SOURCES OF AIR INFILTRATION

Air infiltration is produced by three forces: wind, stack effect and mechanical ventilation. Wind action puts the windward side or half of a house under a positive pressure differential (i.e. outdoor air pressure is greater than indoor) causing a net inward flow of air, and the leeward side under a negative pressure differential, creating a net outward air flow. Stack effect is produced by the indoor over the bottom half of the house and an outflow over the top half. Mechanical ventilation accounts for the air admitted to the house to replace air exhausted through kitchen or bathroom fans.

The primary sources of air infiltration (i.e. where the air actually enters or leaves the house) are listed below in their order of importance:

a) around top and bottom sill plates,

b) past electrical outlets on exterior walls,

c) through breaks in the ceiling vapor barriers caused by ceiling light fixtures, attic hatches, interior partitions, plumbing stacks, etc.

d) through leaky doors and windows,

e) other miscellaneous sources such as chimneys, fireplaces, floor drains, etc.

THE BLOWER DOOR ASSEMBLY

COMPONENTS

The blower door assembly consists of four major components: a collapsible door which fits into the door opening of the test house, an electric blower with speed control to exhaust air from the structure, a bell mouth nozzle to measure the quantity of air being exhausted and a house pressure manometer to determine the indoor to outdoor pressure differential created by the blower. These are illustrated in Figure B1.

Collapsible Door - The door is constructed of plywood and is composed of three hinged sections. When fully extended, its dimensions are 81 cm x 203 cm (32" x 80") - the standard residential door size. The unit is held firmly in place in the opening by four wooden brackets so that a tight seal exists between the door and the opening. When fully collapsed, the unit can be easily transported by one man.

Blower - The blower is permanently bolted to the centre of the collapsible door and has a capacity of approximately 566 l/s (1200 cfm) which is adjustable with the speed controller. The unit exhausts air from the house through the nozzle.

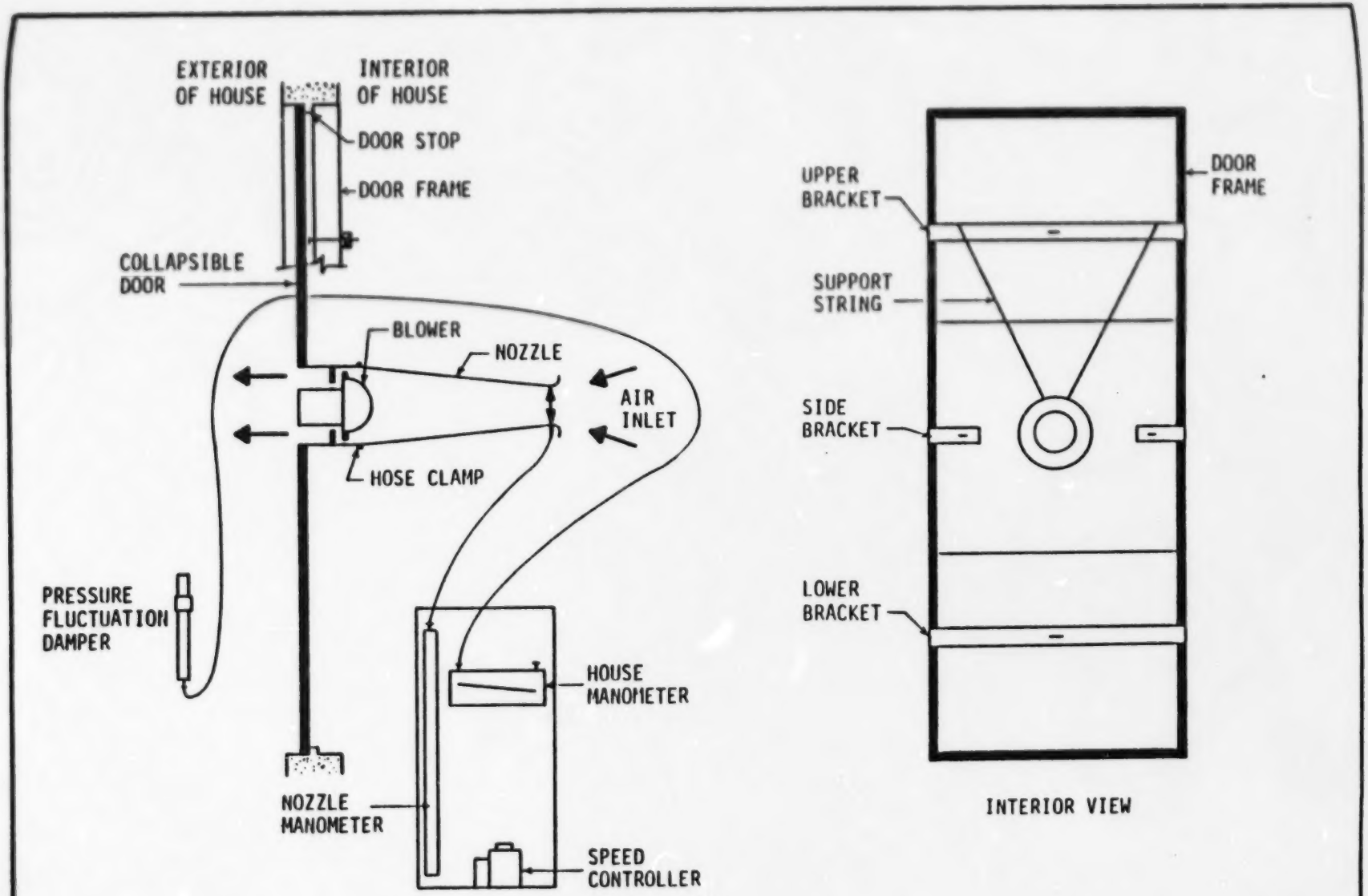
Nozzle - The bell mouth nozzle is constructed of fibreglass with metal flow straighteners. It is affixed to the blower before the test by a single clamp. The quantity of air being exhausted through the blower is accurately determined by measuring the pressure drop at the throat section of the nozzle. Pressure taps at the nozzle throat are hooked up to the low pressure side of a vertical manometer by a single flexible tube. The high pressure side of the manometer is left open to the atmosphere. The nozzle manometer is located in a wooden carrying case with the house pressure manometer.

House Pressure Manometer - This measures the actual indoor to outdoor pressure difference created by the exhaust fan. The indoor tap is left open to room air and the outdoor tap is connected to a pressure fluctuation damper through a 6 M (20') flexible tube. The damper is placed in the yard at a location where the effects of wind turbulence are minimized.

OPERATION

The use of the blower door assembly is straight forward; an entire test from arrival at the house to departure can be performed by one man in one and one-half hours.

Normally, two tests are conducted on each house. The first is done with the chimney and other vents open to simulate the actual operating condition of the house and the second with them closed to evaluate the integrity of the wall, ceiling and floor vapor barriers. The first test may not prove necessary if the investigator is only concerned with studying how uncontrolled leakage through the vapor barrier can be reduced.



BLOWER DOOR ASSEMBLY GENERAL ARRANGEMENT

FIGURE B1

APPENDIX C

AIR LEAKAGE TEST RESULTS

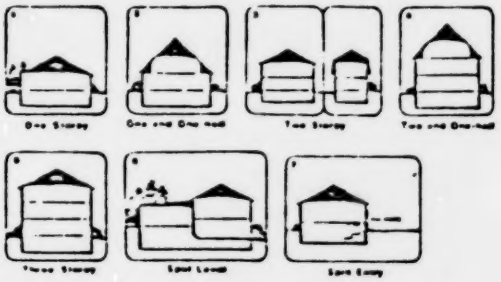
DATE: December 19/80
ADDRESS:
OWNER: Flair Homes

HOUSE DESCRIPTION

1. Year house built? (Approx. date) 1980

2. Type of house?

   If house has an addition that gives it more than one style, mark the style of the main house.



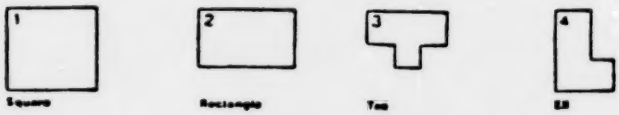
one storey	X
one & half storey	
two storey	
two & half storey	
three storey	
split level	
split entry	

3. Basement:

fully heated	X
partial heated	
area	
crawlspace (unheated)	

4. Basic shape of the ground floor?

   Disregard any unheated porches, garages, sheds, etc. and any small irregularities in shape.



square	
rectangle	X
tee	
ell	
other	

5. Gross heated floor area of the house? (Not including basement) (26 x 40)/10.7 (inside vapour barrier)
   96.65 m^2

6. How are exterior walls constructed?

wood frame	X
solid masonry or stone	
plank frame or solid log	

7. If wood frame, what veneer or siding?

brick	____
wood	____
aluminum	____
stucco	____
vinyl	
none	42.2 m

8. Perimeter of heated portion of house:
   2 (27.58 + 41.58)/3.28

9. Exposed house surface area:
   (based on vapour barrier area) 205 m^2

10. House Volume:
    (inside vapour barrier) 475 m^3

11. Number of windows of type:
(each window frame constitutes one window)

sealed units	4
casement	3
slider	2
awnings	5

Tightness of Windows:

tight	X
average	X
loose	____

12. How is house insulated?
(thickness & material)

Roof: RSI 10.57

Walls: RSI 7.04

Basement: RSI 4.84

13. Type of vapour barrier if any:
6 mil poly, airtight standards

14. Condition of weatherstripping:

good	X
average	____
poor	____

15. Type of heating:

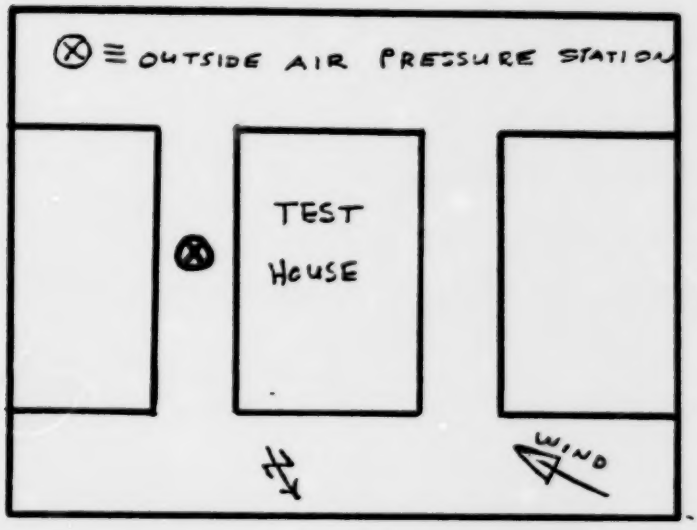
gas	____
oil	____
electric	X
other	____

16. If there are fireplaces, how many? None

17. Is the header space between floor joists accessible?

YES

18. Sketch pertinent features affecting exposure of house to wind, and show prevailing wind direction.



APPENDIX C

Test #2 - February 18, 1981

House Complete: Heat Exchanger Vents and Floor Drain Sealed

$Q = 5.956 \; p^{0.5998}$ (see D)

r^2 = 0.9934 (minimum acceptable value = 0.9800) (see E)

Q_{50} = 0.47 AC/hr (interpreted from test data) (see F)

Q_{10} = 0.18 AC/hr (extrapolated from test data) (see F)

A. House Pressure

This is the envelope pressure produced by the blower door assembly and is measured in Pascals.

B. Nozzle Pressure

This is the pressure created by the air flow at the throat of the nozzle, and is measured in Pascals.

C. Air Flow Rate

The nozzle is a carefully calibrated, long radius ASME nozzle with known characteristics. The relationship between the nozzle pressure and air flow rate has been determined in the laboratory and the nozzle pressure is then used to calculate the corresponding air flow rate.

D. Flow Rate Calibration

Empirically-derived calibration formula used to calculate the flow rate, Q, from pressure differential data.

E. Correlation Coefficient (r)

In order to determine the accuracy of the pressurization data, some indication of how well the points 'fit' on a straight line must be included. The determination of the correlation coefficient is a complicated but very accurate means of ensuring an acceptable 'fit'. If the value of r is less than 0.9800 the leakage test must be repeated.

F. Air Change Rate

The air change rate is the number of times that the entire air volume within the structure changes each hour at a specific pressure differential. The pressure differential of 50 Pascals is selected to conform with the reference pressure used internationally to report air change rates. This value is determined by dividing the air flow rate per hour at a 50 Pascal pressure differential by the heated volume of the structure.

Residential Air Leakage Test Data

Date: February 18, 1981
Address:
Name of Owner: Flair Homes

TEST #2

Atmospheric Conditions: Cloudy
Temperature: 0 C
Wind: 5 km/h

Note: House Completed

UNSEALED			HEAT EXCHANGER VENTS and FLOOR DRAIN SEALED		
House Pressure (Pascals)	Nozzle Pressure (Pascals)	Air Flow (Litres/Second)	House Pressure (Pascals)	Nozzle Pressure (Pascals)	Air Flow (Litres/Second)
20	17	60.2			
40	40	92.1			
60	64	116.4	60	22	68.4
80	90	137.9	80	32	82.4
100	120	159.1	101	42	94.4
91	102	146.7	111	49	101.9
71	7	129.2	90	37	88.6
50	52	104.9	69	26	74.3
31	31	81.1	50	19	63.6
113	147	176.0			

APPENDIX D

HOTCAN ANALYSIS

APPENDIX D

HOTCAN ANALYSIS
NATIONAL RESEARCH COUNCIL OF CANADA

CLIENT NAME: Flair Homes Ltd., Winnipeg

BUILDING PARAMETERS

ELEMENT	AREA m^2	RSI VALUE m^2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	92.61	10.57		
TOTAL	92.61	10.57	8.76	8.00
MAIN WALLS	87.91	7.04		
TOTAL	87.91	7.04	12.49	11.40
DOORS	3.41	1.76		
TOTAL	3.41	1.76	1.94	1.77
BASEMENT AB.GD.	14.25	3.72		
TOTAL	14.25	3.72	3.83	3.50
BASEMENT 600 MM.	25.32	4.84		
TOTAL	25.32	4.84	4.16	3.19
BASE TO FLOOR	60.55	4.02		
TOTAL	60.55	4.02	8.73	6.70
FLOOR PERIMETER	42.20	0.00		
TOTAL	42.20	0.00	30.48	23.38
FLOOR CENTRE	46.60	0.00		
TOTAL	46.60	0.00	10.48	8.04
SOUTH WINDOWS	6.82	.57		
TOTAL	6.82	.57	11.96	10.92
NORTH WINDOWS	0.00	.00		
TOTAL	0.00	.00	0.00	0.00
EAST WINDOWS	1.95	.57		
TOTAL	1.95	.57	3.42	3.12
WEST WINDOWS	1.95	.57		
TOTAL	1.95	.57	3.42	3.12
AIR CHANGE	.13/HR	475.00 M3	18.46	16.85

Design heat loss at -31.7C = 4.37 kW
Temperatures (DEG C) main floor = 21.0 Basement = 18.0
Sensible heat gain from people (kW.h/D) = 3.20
Daily base electrical consumption (kW.h/D) = 14.00
Daily hot water energy consumption (kW.h/D) = 14.00
Mass level chosen is (A)
Window Shading Coefficients: South = .71 North = 0.00
East = .50 West = .50
South overhang geometry: Average window height = 1.67 M
Average overhang width = .15 M
Average height above window = .31 M
Natural infiltration rate (AC/HR) = .03
Forced ventilation rate (AC/HR) = .32
Heat recovery effectiveness on ventilation air = 70%

MONTHLY SUMMARY OF ENERGY CONSUMPTION

MONTH	THERMAL LOAD kW.h/D	MONTHLY SOLAR FRAC	AUX. HEAT REQ. kW.h/D	TOT CONS kWh/D
Jan.	63.59	.264	46.79	74.79
Feb.	60.75	.34	39.85	67.85
Mar.	48.97	.441	27.39	55.39
Apr.	30.12	.551	13.53	41.53
May	16.73	.727	4.56	32.56
June	5.20	1.000	0.00	28.00
July	0.00	1.000	0.00	28.00
Aug.	0.00	1.000	0.00	28.00
Sept.	8.03	.964	.29	28.29
Oct.	18.55	.680	5.94	33.94
Nov.	37.65	.318	25.67	53.67
Dec.	54.42	.259	40.33	68.33

Estimated annual space heating 22.23 GJ, or 6176.1 Kilowatt Hours
Annual solar fraction = .406
Total annual energy consumption = 16396. Kilowatt Hours
S.E.E.H. program requirements for total energy consumption = 19942. Kilowatt Hours

ANNUAL PREDICTED FUEL COSTS

Fuel Costs are for Winnipeg As of Oct/82

ENERGY SOURCE	COST PER UNIT	SPACE HEATING	HOT WATER	LIGHTS AND APPLIANCES
Electricity	2.53¢/kW.h	$156.25/yr Eff.=100%	$129.28/yr Eff.=100%	$129.28/yr Eff.=100%
Natural Gas	17.62¢/m^3	$150.20/yr Eff.=70%	$158.17/yr Eff.=55%	--
Oil	31.9¢/Litre	$259.81/yr Eff.=70%	$273.59/yr Eff.=55%	--
Propane	10.0¢/Litre	$124.07/yr Eff.=70%	$130.65/yr Eff.=55%	--
Wood	$10.0/$m^3$	$ 86.78/yr Eff.=50%	$ 89.75/yr Eff.=40%	--

APPENDIX E

PHOTOGRAPHS

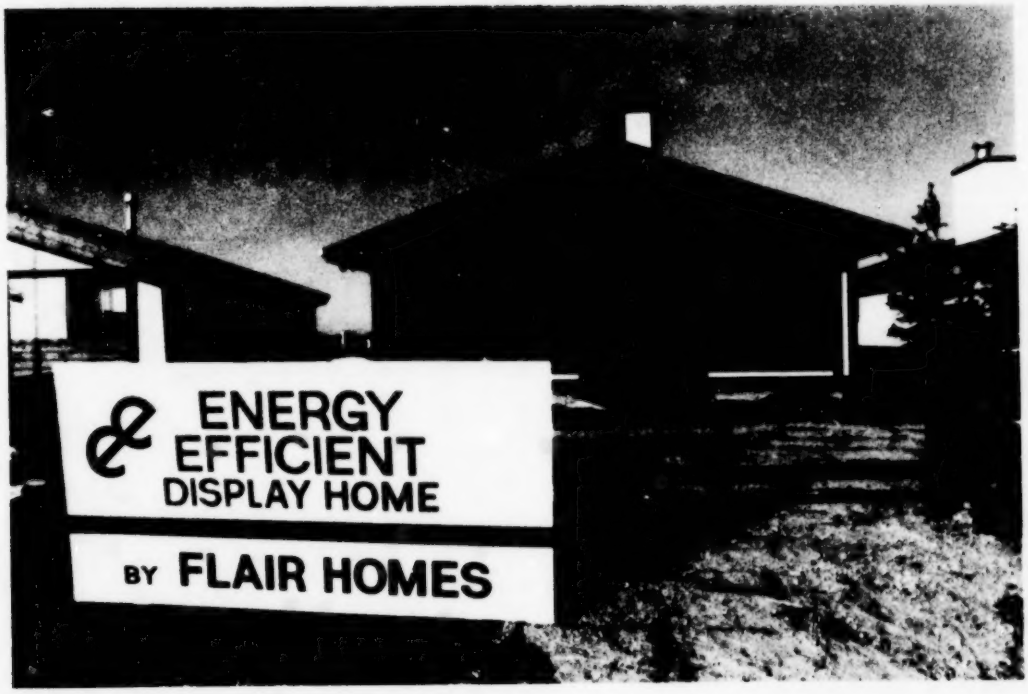


FIGURE A: FRONT (SOUTH SIDE) VIEW OF HOUSE

FIGURE B: REAR (NORTH SIDE) VIEW OF HOUSE

FIGURE C: UNIVERSITY OF SASKATCHEWAN
AIR-TO-AIR HEAT EXCHANGER

FIGURE D: FRONT WINDOW

FIGURE E: LIVING ROOM

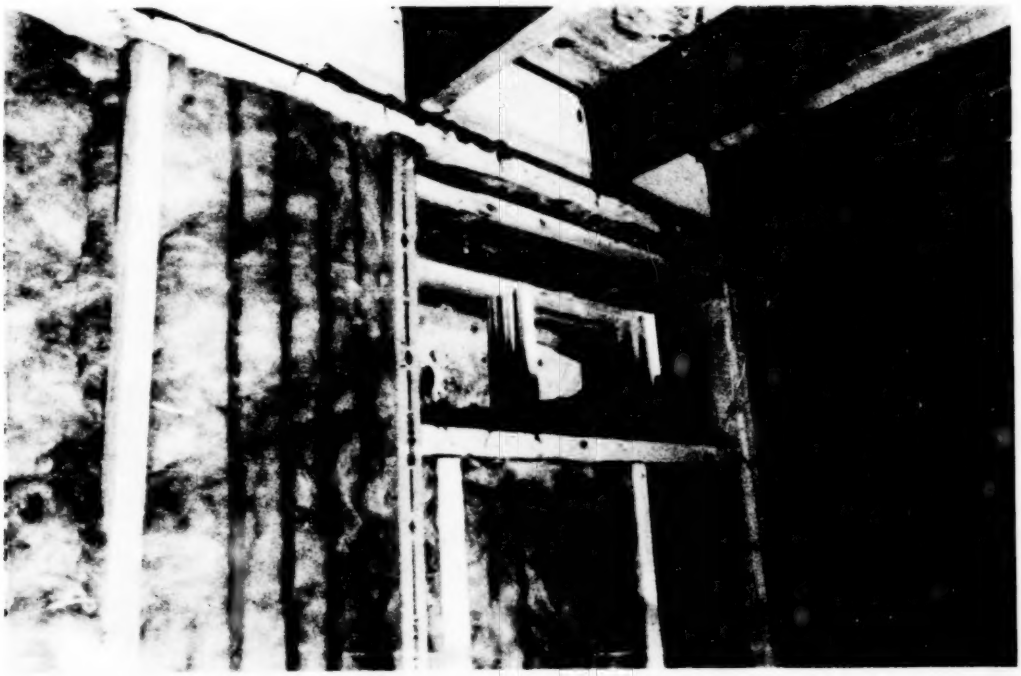


FIGURE F: UNFINISHED BASEMENT

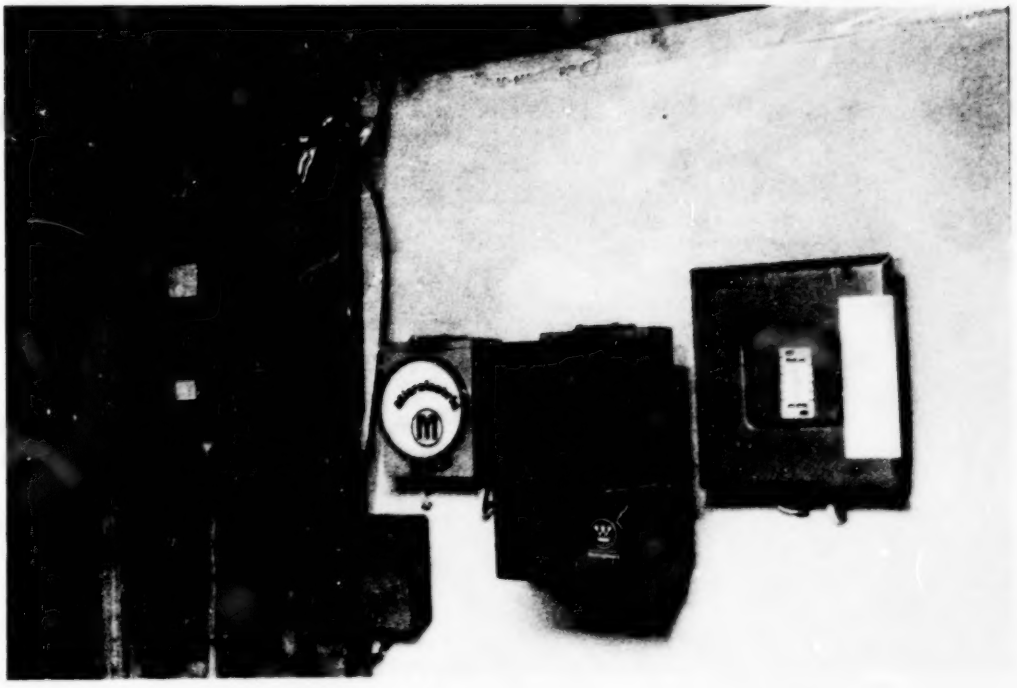


FIGURE G: ELECTRICAL PANELS AND METERS FOR MONITORING

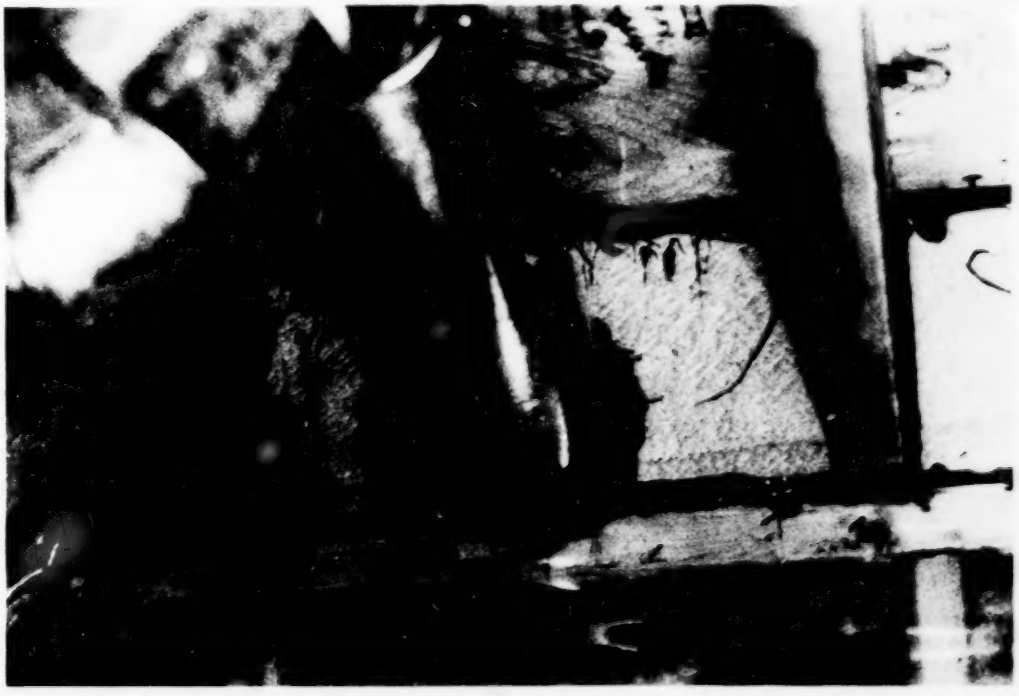


FIGURE H: HEAT EXCHANGER DUCT
(Note extensive caulking)

Canada

Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

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DEPARTMENT OF ENERGY AND MINES